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If you have a question or problem that your fellow readers might help you to solve, please forward it to us. At the same time, feel free to respond to any of the questions that you have read here. Contact *Steel Interchange* via AISC's Steel Solutions Center:

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## GALVANIZED STEEL

Philip G. Rahrig, Executive Director at the American Galvanizers Association, www.galvanizeit.org, contributed this month's *Steel Interchange*, pertaining to galvanizing.

**How does galvanizing protect steel from corrosion?**

Zinc metal used in the galvanizing process provides an impervious barrier between the steel substrate and corrosive elements in the atmosphere. It does not allow moisture and corrosive chlorides and sulfides to attack the steel. Zinc is more importantly anodic to steel—meaning it will corrode before the steel, until the zinc is entirely consumed.

**What are the steps in the galvanizing process?**

There are four steps:

*Pre-inspection*—where the fabricated structural steel is viewed to ensure it has, if necessary, the proper venting and draining holes, bracing, and overall design characteristics necessary to yield a quality galvanized coating

*Cleaning*—steel is immersed in a caustic solution to remove organic material such as grease and dirt, followed by dipping in an acid bath (hydrochloric or sulfuric) to remove mill scale and rust, and finally lowered into a bath of flux that promotes zinc & steel reaction and retards further oxidation of the steel … (steel will not react with zinc unless it is perfectly clean)

*Galvanizing*—the clean steel is lowered into a kettle containing 850 F molten zinc where the steel and zinc metallurgically react to form three zinc-iron intermetallic layers and one pure zinc layer

*Final inspection*—the newly galvanized steel is sight-inspected (if it looks good, it is), followed up by measurement of coating thickness with a magnetic thickness gauge

**Is there any environmental impact when the zinc coating sacrificially corrodes? Is zinc a safe metal?**

There are no known studies to suggest zinc corrosion products cause any harm to the environment. Zinc is a naturally occurring element (25$^{th}$ most abundant element in the earth), and necessary for all organisms to live. It is a recommended part of our diet (RDA 15 mg) and necessary for reproduction. It is used in baby ointments, vitamins, surgical instruments, sunscreens and cold lozenges.

**Should I be concerned when galvanized steel comes in contact with other metals?**

Zinc is a noble metal and will sacrifice itself (i.e. corrode, give up its electrons and create a bi-metallic couple) to protect most metals. So, it is recommended to insulate galvanized steel so that it doesn't come in direct contact with dissimilar metals. Rubber or plastic, both non-conductive, are often used to provide this insulation.

**What is the difference between hot-dip galvanizing after fabrication and continuous hot- galvanized sheet?**

The process steps are similar but the production equipment is very different. After fabrication galvanizing is a more manual process where structural steel (fabricated plate, wide-flange beams, angles, channels, tube, pipe, fasteners) is suspended by wire, chain or hook from crane hoists and immersed in the cleaning solutions and zinc. Continuous sheet galvanizing involves uncoiling sheet, passing it through the cleaning steps and molten zinc bath at speeds up to 500 feet per minute, drying and recoiling.

The uses of after-fabrication galvanized steel are usually exterior in nature because the zinc coating is relatively thick (3.0 to 6.0 mils, 75 to 150 microns, 1.7 to 3.6 oz/sq. ft) and will protect steel from corrosion in most atmospheric conditions for 50 to 100 years. Galvanized sheet is suitable for interior applications because of the relatively thin coating (0.45 oz on each side), unless it is painted after galvanizing.

**Does the galvanized steel coating of zinc resist abrasion?**

The three intermetallic layers that form during the galvanizing process are all harder than the substrate steel and have excellent abrasion resistance.

**What is a G90 or A60 coating?**

G90 is a grade of galvanized sheet produced to ASTM A653. It has 0.90 oz/sq. ft of zinc overall or 0.45 oz/sq. ft per side. A60 is also a grade, has 0.30 oz/sq. ft per side, and has been annealed after galvanizing to produce a surface that promotes good adhesion of paint.

**Is a salt spray test in a laboratory appropriate to estimate the corrosion rate of zinc coated steel?**

In order for zinc to develop its protective patina of zinc carbonate that is very stable and non-reactive, it requires a wetting and drying cycle like that produced by nature. Salt spray tests keep the zinc wet and essentially wash the zinc

corrosion products off as they develop, inflating the corrosion rate of zinc. This lab test is not reflective of real-world performance of zinc coatings.

**What causes wet storage stain and how can it be prevented?**

Zinc on newly galvanized steel is very reactive and wants to form zinc oxide and zinc hydroxide corrosion products that eventually become the stable zinc carbonate. When galvanized steel is tightly stacked or stored in wet boxes that don't allow for free flowing air, the zinc forms excessive layers of zinc hydroxide, otherwise known as wet storage stain. Most wet storage stain can be easily removed with a cleaner or nylon brush. To prevent wet storage stain, store galvanized steel indoors or block it so that there is ample free flowing air between each galvanized article.

**Why do galvanized steel appearances differ from project to project and galvanizer to galvanizer and is there any difference in the corrosion protection offered by the different appearing coatings?**

The steel chemistry is the primary determinant of galvanized coating thickness and appearance. Continuously cast steel produced by the steel companies has a wide variety of chemistries, thus the different coating appearances.

There are several different additives that galvanizers may put in their zinc kettle to enhance the coating appearance by making it shiny, spangled or matte gray.

The appearance of the coating (matte gray, shiny, spangled) does nothing to change the corrosion protection of the zinc coating.

**How well does galvanized steel perform in permanent water immersion?**

Galvanized steel performs very well in many complete immersion applications. There are numerous variables that determine just how long, including pH, available chlorides, hardness, and temperature. It should be noted that at the tidal or wake line, galvanized coatings don't last very long because the zinc corrosion products are essentially washed off the steel, not allowing the stable protective zinc carbonate patina to form.

**Can galvanized steel in service withstand high temperatures for long periods of time?**

Constant exposure to temperatures below 390 °F (200 C) is a perfectly acceptable environment for hot-dip galvanized steel. Good performance can also be obtained when hot-dip galvanized steel is exposed to temperatures above 390 °F (200 C) on an intermittent basis.

**Why would you want to paint over galvanized steel?**

Called duplex coatings, zinc and paint in combination (synergistic effect) produce a corrosion protection approximately two times the sum of the corrosion protection that each alone would provide. Additionally, duplex coatings make for easy repainting, excellent safety marking systems, and good color-coding. Painting over galvanized steel that has been in service for many years also extends the life of the zinc coating.

**What are the specifications governing hot-dip galvanized steel?**

- Structural steel (plate, wide-flange beams, angles, channels, pipe, tubing) are galvanized to ASTM A 123/A 123M.
- Fasteners and small parts that fit into a centrifuging basket are galvanized to ASTM A 153/A 153M.
- Reinforcing steel is galvanized to ASTM A 767/A 767M.

**Isn't galvanizing more expensive than paint?**

Depending on the product mix, square feet per ton, and condition of the steel surface, galvanizing is often less expensive on an initial cost basis. However, as with any purchase, the lifetime costs should be considered when making a project decision on the corrosion prevention system to utilize. And, with galvanizing, the life cycle cost, i.e. the cost per year to maintain, is almost always less than a paint system. Paint systems require maintenance, partial repainting and full repainting several times over a 30-year project life. The costs can be staggering, making the decision to paint a costly one in the long run.

**What if the article to be galvanized is larger than the dimensions of the galvanizer's kettle? Can it still be galvanized?**

Galvanizers can progressively dip such a fabrication or article of steel. They dip one half in the molten zinc bath, remove it, turn it around or over and immerse the other half in the zinc. This method is often erroneously referred to as "double dipping."

**Can I specify how much zinc to put on the steel?**

No, the steel chemistry and surface condition are the primary determinants of zinc coating thickness. Leaving the steel in the molten zinc a little longer than optimal may have one of two effects: 1) it may increase the coating thickness, but only marginally, or 2) it may significantly increase the coating thickness and cause a brittle coating.

**What is the difference between hot-dip galvanized fasteners and zinc-plated fasteners?**

Hot-dip fasteners generally have about 10 times as much zinc on the surface and are suitable for use in all exterior and interior applications. Zinc-plated fasteners will provide a disappointing performance if used outside, especially when used to connect hot-dip galvanized structural steel members.

**What is "cold" galvanizing?**

There is no such thing as cold galvanizing. The term is often used in reference to painting with zinc-rich paint. Galvanizing by definition means a metallurgical reaction between zinc and iron to create a bond between the zinc and the steel of approximately 3600 psi. There is no such reaction when zinc-rich paints are applied and the bond strength is only several hundred psi.